

## CLAIMS

What is claimed is:

1 1. A method to stabilize high aspect ratio, post-etch lithographic feature against collapse,  
2 the method comprising the steps of:  
3 (a) coating a substrate with a substantially organic underlayer;  
4 (b) coating said underlayer with a photoresist comprising materials that form a stable,  
5 etch-resistant, non-volatile oxide;  
6 (c) imagewise exposing said photoresist to radiation;  
7 (d) developing an image in said photoresist;  
8 (e) transferring said image through said underlayer into said substrate thus forming a  
9 high aspect ratio resist image; and  
10 (f) treating said high aspect ratio resist image with a chemically-reducing plasma.

1 2. A method to stabilize high aspect ratio, post-etch lithographic feature against collapse,  
2 according to claim 1, wherein said photoresist comprises an element capable of forming a  
3 stable, etch-resistant, non-volatile oxide selected from the group consisting of silicon,  
4 phosphorous, germanium, aluminum, and boron.

1 3. A method to stabilize high aspect ratio, post-etch lithographic images against  
2 collapse, according to claim 1, wherein said bilayer resist comprises:  
3 an organic underlayer formed on said substrate; and  
4 a photoresist comprising materials that form a stable, etch-resistant, non-volatile oxide  
5 formed on said underlayer.

1 4. A method to stabilize high aspect ratio, post-etch lithographic images against  
2 collapse, according to claim 1, wherein transferring said image comprises etching wherein  
3 said etching comprises passivating chemistry.

1 5. A method to stabilize high aspect ratio, post-etch lithographic images against  
2 collapse, according to claim 3, wherein passivating chemistry comprises any process that  
3 generates hygroscopic moieties.

6. A method to stabilize high aspect ratio, post-etch lithographic images against collapse, according to claim 3, wherein passivating chemistry comprises an SO<sub>2</sub> and O<sub>2</sub> containing plasma.
7. A method to stabilize high aspect ratio, post-etch lithographic images against collapse, according to claim 1, wherein said chemically-reducing plasma comprises hydrogen.
8. A method to stabilize high aspect ratio, post-etch lithographic images against collapse, according to claim 1, wherein said chemically-reducing plasma comprises a hydrogen-generating species.
9. A method to stabilize high aspect ratio, post-etch lithographic images against collapse, according to claim 1, wherein said underlayer comprises an organic material selected from the group consisting of tuned polymers, novolacs, and low-k dielectrics.
10. A method to stabilize high aspect ratio, post-etch lithographic images against collapse, according to claim 1, wherein said underlayer comprises an organic material essentially comprising carbon, hydrogen, and oxygen.
11. A method to stabilize high aspect ratio, post-etch lithographic images against collapse, according to claim 1, wherein said photoresist comprises a polymer having acid-cleavable moieties bound thereto.
12. A method to stabilize high aspect ratio, post-etch lithographic images against collapse, according to claim 1, wherein said photoresist comprises a polymer formed by polymerizing one or more monomers selected from the group consisting of acrylate, methacrylate, hydroxystyrene optionally substituted with C<sub>1-6</sub>-alkyl, C<sub>5-20</sub> cyclic olefin monomers, and combinations thereof, the polymer having acid-cleavable moieties bound thereto, wherein all such moieties are silylethoxy groups optionally substituted on the ethoxy portion thereof with C<sub>1-6</sub>-alkyl, phenyl, or benzyl.
13. A method to stabilize high aspect ratio, post-etch lithographic images against collapse, according to claim 1, wherein said photoresist comprises a radiation-sensitive acid generator.

- 1 14. A method to stabilize high aspect ratio, post-etch lithographic images against  
2 collapse, according to claim 1, wherein said radiation comprises electromagnetic radiation or  
3 electron beam radiation.
- 1 15. A method to stabilize high aspect ratio, post-etch lithographic images against  
2 collapse, according to claim 1, wherein said radiation comprises ultraviolet radiation or  
3 extreme ultraviolet radiation.
- 1 16. A method to stabilize high aspect ratio, post-etch lithographic images against  
2 collapse, according to claim 1, wherein said radiation comprises x-ray radiation.
- 1 17. A method to stabilize high aspect ratio, post-etch lithographic images against  
2 collapse, according to claim 1, wherein transferring said image further comprises forming a  
3 reduced critical dimension bilayer resist image.
- 1 18. The stabilized high aspect ratio, post-etch lithographic image formed according to  
2 claim 1.
- 1 19. The semiconductor device fabricated using the stabilized high aspect ratio image  
2 formed according to claim 1.
- 1 20. A method of fabricating semiconductor devices using a stabilized, high aspect ratio  
2 bilayer resist image comprising the steps of:  
3 (a) coating a substrate with an organic underlayer;  
4 (b) coating said underlayer with a photoresist comprising a material that form a stable,  
5 etch-resistant, non-volatile oxide;  
6 (c) imagewise exposing said photoresist to radiation;  
7 (d) developing an image in said photoresist;  
8 (e) transferring said image through said underlayer into said substrate thus forming a  
9 high aspect ratio resist image;  
10 (f) treating said high aspect ratio resist image with a chemically-reducing plasma;  
11 (c) transferring said image into said substrate forming a circuit image; and  
12 (d) forming circuit element materials in said circuit image.

1 21. A method of fabricating semiconductor devices using a stabilized, high aspect ration  
2 bilayer resist image, according to claim 20, wherein said circuit element materials comprise  
3 materials selected from the group consisting of dielectric, conductor, semiconductor, and  
4 doped semiconductor materials.

1 22. The stabilized high aspect ratio, post-etch lithographic image formed according to  
2 claim 1, wherein said resist is a trilayer resist.

1 23. The stabilized high aspect ratio, post-etch lithographic image formed according to  
2 claim 22, wherein said trilayer resist comprises:  
3 an organic resist;  
4 an anti-reflective coating;  
5 an inorganic hard mask; and  
6 a thick organic layer.

1 24. The stabilized high aspect ratio, post-etch lithographic image formed according to  
2 claim 23, wherein said hard mask comprises silicon.

1 25. The semiconductor device fabricated using a reduced critical dimension bilayer resist  
2 image, according to claim 20.

1 26. The semiconductor device fabricated using a stabilized high aspect ratio, post-etch  
2 lithographic image formed according to claim 23.